

Testing a word is not a test of word learning

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Testing a Word is Not a Test of Word Learning

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Abstract

Although vocabulary acquisition requires children learn names for multiple things, many investigations of word learning mechanisms teach children the name for only one of the objects presented. This is problematic because it is unclear whether children's performance reflects recall of the correct word-object association or simply selection of the only object that was singled out by being the only object named. Children introduced to one novel name may perform at ceiling as they are not required to discriminate on the basis of the name per se, and appear to rapidly learn words following minimal exposure to a single word. We introduced children to four novel objects. For half the children, only one of the objects was named and for the other children, all four objects were named. Only children introduced to one word reliably selected the target object at test. This demonstration highlights the oversimplicity of one-word learning paradigms and the need for a shift in word learning paradigms where more than one word is taught to ensure children disambiguate objects on the basis of their names rather than their degree of salience.

Testing a Word is Not a Test of Word Learning

1 Introduction

Building a vocabulary is a critical and impressive early childhood accomplishment, considered both “remarkable” (Waxman & Booth, 2000) and “amazing” (Graham, Poulin-Dubois & Baker, 1998). For example, during toddlerhood children’s productive vocabularies increase from roughly three words at 12 months of age and up to 570 words at 30 months of age (Fenson et al., 1994). Based on the sheer rate of vocabulary acquisition such as that seen during the ‘vocabulary explosion’ (Fenson et al., 1994; Hamilton, Plunkett, & Schafer, 2000), children must learn the meanings of *multiple* words in parallel (McMurray, 2007). Nevertheless, attempts to uncover the mechanisms that support children’s exponential word learning typically present children with multiple objects but only teach children only a *single* novel word.

When children are introduced to only one name in the context of multiple novel objects, they appear to learn that name well. For example, in an influential paper on domain-general learning mechanisms, Markson and Bloom (1997) introduced 3- and 4-year-old children to multiple objects but only named one of them and found that children successfully selected the target up to one month after the original naming episode. Comparable comprehension accuracy has been observed after 30-month-old children were directly addressed or listened in on a conversation (Akhtar, Jipson, & Callanan, 2001), and after they received distributed and massed exposures to the new word (Childers & Tomasello, 2002). These studies suggest that young children are adept at retaining a single new word across a variety of learning situations (see Horst & Samuelson, 2008, for a review).

However, when only one of multiple objects is named and children proceed to select the correct target at test, it is unclear whether children have really learned the correct word-object association and are not simply selecting the target object because it was singled-out by being the only object named during training. Naming increases children's attention to novel objects (e.g., Baldwin & Markman, 1989; Martínez-Sussman, Akhtar, Diesendruck, & Markson, 2011; Mather & Plunkett, 2009). Consequently, a target object may be chosen simply because it appeared more salient and memorable because it was the only object named. Therefore, what should be a test of word learning may become a test of recalling which object was given special treatment. This kind of test is simpler than a test of word learning and may lead children to perform at ceiling. This may explain some of the conflicting findings in the child word learning literature, such as outstanding retention after one week or even one month when tested on a single target (e.g., Childers & Tomasello, 2002; Markson & Bloom, 1997; Waxman & Booth, 2000), but poor retention after shorter intervals such as 5 minutes when tested on multiple targets (Gurteen, Horne, & Erjavec, 2011; Horst & Samuelson, 2008; Wilkinson, Ross, & Diamond, 2003).

To ensure that children are not choosing the correct object for the wrong reason, rigorous tests of word learning must treat all of the test objects equivalently; each should serve as both a target and a competitor. Naming each test alternative helps ensure children are selecting a target object in response to the phonetic content of its name and not its salience during training or because it was the object most recently presented with a name (Axelsson, Churchley, & Horst, 2012; Dollaghan, 1985; Schafer & Plunkett, 1998; Wilkinson et al., 2003). Such tests of word learning in which more than one of the objects are named, however, have typically failed to produce evidence of significant word learning unless highly salient ostensive naming

is provided with 2-year-old children (Horst & Samuelson, 2008; Horst, Scott, & Pollard, 2010), memory supports such as increased saliency and repetition with 3-year-old children (Vlach & Sandhofer, 2012), or as many as 12 repetitions with 13- to 17-month-old toddlers (Gurteen et al., 2011; Schafer & Plunkett, 1998).

If treating all of the test alternatives equivalently leads to a more robust test of word learning than singling out one particular named object, then we should expect children to perform differently in these two styles of experiments. To demonstrate this difference we presented two groups of children with the same objects and either named only one object or named all of the objects present. We presented children with *four objects* because this is common in the literature (e.g., Akhtar & Tomasello, 1996; Akhtar et al., 1996; Diesendruck et al., 2004; Moore, Angelopoulos, & Bennett, 1999; Samuelson & Smith, 1998), and because we wanted to use an established method (Akhtar et al., 2001). Moreover, recent research suggests that more than four objects can be too distracting for children even up to 38 months of age (Zosh, Brinster, & Halberda, 2013). Importantly, all children received the same exposure to the four novel objects. However, half of the children were taught one name with the target being the only object named (one word condition); and half of the children were taught one name per object and all of the objects were treated equivalently (four words condition). We chose a maximum of *four words* because current estimates suggest that young children (18- to 30-month-olds) can learn up to four words each day (Bion, Borovsky, & Fernald, 2013; Mayor & Plunkett, 2011), and recent research suggests that 24-month-old children may be able to learn up to four words during an experimental session (Horst & Samuelson, 2008). We tested 2-year-old children because they can complete this task easily without becoming overly tired (e.g., Akhtar et al., 2001) and findings with children in this age group would likely generalize to

older children who have even better language skills and working memory capacity. We predicted that only children who were introduced to a single word would demonstrate significant target selection, that is, would perform at above chance levels on a novel name recall test.

2 Method

2.1 Participants. Twenty-four typically-developing children between 22 and 31 months of age ($M = 26\text{m}, 22\text{d}$, $SD = 2\text{m}, 22\text{d}$; 11 girls, 13 boys) participated, and were randomly assigned to either the One Word or Four Words conditions. There was no significant difference in age across the two conditions (one word: $M = 27\text{m}, 10\text{d}$, $SD = 2\text{m}, 16\text{d}$; 23m, 0d – 31m, 3d; four words: $M = 26\text{m}, 3\text{d}$, $SD = 2\text{m}, 26\text{d}$; 22m 1d – 31m, 24d, $t(22) = 1.12$, *ns.*). Parents were reimbursed for travel expenses and children received a small gift for participating.

2.2 Stimuli. Four novel, unfamiliar toys served as stimuli: a red, plus-sign-shaped top (*blicket*), a beaded metal spaceship-shape (*chatten*), a blue, plastic rod with a weighted ball on one end (*pizer*), and an orange, birdtoy with rope extending from a cone (*toma*). Word-object pairs were held constant to minimize experimenter error (Capone & McGregor, 2005). Four familiar objects also served as stimuli: a block, a cow, a cup, and a train. Four identical opaque, handle-less yellow buckets were used to conceal the objects during the learning phase.

2.3 Learning Phase. The experiment began with the learning phase. The experimenter sat opposite the child and set the four buckets in front of herself, but out of the child's reach. The experimenter first presented the familiar objects, then the novel objects using the same procedure. Each familiar object was shown once. To show an object, the experimenter removed the object from its bucket and let the child handle it while

she named it using a set script “Ooh, look at the (*name*). Yeah, see the (*name*). Wow, look at the (*name*).” (see Woodward, Markman, & Fitzsimmons, 1994). The experimenter replaced each object before continuing; thus only one object was visible at a time.

After the child had seen all four familiar objects, the experimenter removed the buckets and exchanged the familiar objects for the novel objects and replaced the buckets on the table. Then, the experimenter presented the novel objects. Each novel object was shown successively (e.g., *blicket*, *chatten*, *pizer*, *toma*) in two presentation rounds in the same order using the same procedure (Akhtar et al., 2001). In the one word condition, only one of the objects was named and “this one” was used for the other objects. In the four words condition, all four objects were named. Word order and the locations of the objects were counterbalanced across participants. In the one word condition, the one object that was named and its location was also counterbalanced across participants (Table 1). The experimenter always presented objects from left-to-right to minimize experimenter error (Akhtar et al., 2001).

2.4 Test Phase. The test phase began immediately after the learning phase. To familiarize the child with the recall task, four warm-up trials were presented using the same four familiar objects from earlier, on a tray divided into four parallel compartments. On each trial, all four objects were placed on a tray and children were asked to “get the (*name*).” Each object was requested once and served as a foil on the other trials. Across trials, the same objects were presented but in different locations. Children received feedback on the warm-up trials with the familiar objects.

The novel word test trials immediately followed the warm-up trials using the same procedure except that children did not receive any feedback. In the one word condition, children received one test trial and in the four words condition, children

received four novel name test trials (one for each named object). The words were presented in the same order (but not same locations) as in the learning phase to keep the timing between first encounter and test the same for all words (Mather & Plunkett, 2009). As on the warm-up trials, each object was requested once and served as a foil on the other trials, and object locations were changed on each trial.

3. Results

Children in the two conditions were essentially presented with different tests and also provided different types of data. Children in the one word condition provided categorical data because they received only one test trial, while children in the four words condition provided continuous data because they received four test trials. Due to these differences we use different analyses to understand children's performance. First, to determine whether children selected the target object(s) at greater than chance levels, we use a binomial test on the categorical data (one word condition) and a one-sample t-test on the continuous data (four words condition). Next, to determine if there are differences between groups, we use Fisher's Exact Test and only consider data from the first test trial so that each condition is treated equivalently and is contributing the same amount of data to the analysis. Finally, as an additional control, we repeat this analysis on yoked words.

Eleven of the 12 children in the one word condition selected the target object, significantly more than would be expected by chance (see Figure 1, Panel A; exact binomial, $p < .001$). In contrast, children introduced to four new words failed to select the target objects at greater than chance levels, $t(11) = 0.82$, $p = .43$, $d = 0.24$. This suggests that children only demonstrated successful target selection when introduced to a single word.

Recall, children in the one word condition provided categorical data and children in the four words condition provided continuous data. To compare target selection accuracy between groups using the same statistical test, we compared performance on the first test trial (see Figure 1, Panel B), which occurred at the same point during the experiment for both groups. Fisher's Exact Test revealed a significant association between the number of words taught and the frequency of target selection, $p = .027$.

However, as a comparison of Figure 1 Panels A and B alludes, a slightly different picture of the accuracy of the children in the four words condition is obtained depending on the number of test trials reported. If we had only tested these children on one word, that is, if we had ended the experiment after the first test trial, then we would have reported that 41.67% of children were accurate (cf. Panel B). However, because we tested children on all four words, that is, all four test trials were reported, an average of 31.25% of children were accurate (Panel A). We should put more trust in the average across all four test trials because it includes more data points from each child. In the current study, 5 out of 12 children were correct on their first test trial, as compared to 3 out of 12 on the second and third trials, and 4 on the fourth trial. This pattern of results is consistent with recent pilot findings reported by Zosh et al., (2013) that performance is better on a single test trial than across multiple test trials—even when the same number of words are introduced during the learning phase and the test phase.

Finally, although the first test trial occurred at the same point during the experiment for both groups, the object that was tested on this trial varied. Recall, to keep the timing between the first encounter and test the same for all words in the four words condition (see Mather & Plunkett, 2009), children in the four words condition

were tested on the novel names in the order they had heard them introduced (i.e., the first object named was the target on the first test trial). Put another way, the target on their first test trial was the object from the first bucket. However, for children in the one word condition, we counterbalanced which of the four objects was named. Thus, the target on the first test trial could have been from any bucket (i.e., first, second, third, fourth). Auspiciously, however, the children were effectively yoked because we took the orders for the four words condition and systematically replaced three of the names with “that one” to create the test orders for the one word condition. For example, a child in the one word condition only heard the name *pizer* and saw the diver (*pizer*) in the third bucket and a child in the four words condition heard all four names, but also saw the diver in the third bucket. As an additional control, we also compared performance on these yoked words. Fisher’s Exact Test revealed a significant association between the number of words taught and the frequency of target selection, $p = .009$. Overall, then, children were significantly more successful at selecting the correct target when introduced to only one novel name. Across multiple analyses we have demonstrated a consistent and robust pattern of results: correct responses are significantly higher when one test item is singled out than if all of the items are treated equivalently. We take this as direct evidence that the tests are inherently different.

4. Discussion

Many investigations into how children learn words typically introduce children to multiple novel objects, but name only a single new word, which is problematic for both experimental control and task validity (Dollaghan, 1985; Schafer & Plunkett, 1998). When children select the target object at test it is unclear if they

are demonstrating that they have learned the correct word-object association or if they are simply selecting the target object because it was singled-out by being the only object named during training. Children appear to perform at ceiling with minimal differences between conditions (e.g., Markson & Bloom, 1997), leading to an inflated sense of how easily children learn words.

This argument has been put forth previously (e.g., Dollaghan, 1985; Schafer & Plunkett, 1998; Wilkinson et al., 2003), however, the current paper is the first to provide supporting evidence for the differences between tests when a single target is singled out versus when all of the test alternatives are treated equivalently. We presented children with four novel objects and either introduced a name for only one object or introduced names for all four objects. As expected, children in the one word condition demonstrated significantly better target selection suggesting that children are more likely to select a target when only a single novel object is named as opposed to when all of the objects are named.

However, it is still unclear whether the children in the one word condition really *learned* the novel word. Although all children were presented with the same objects and same instructions, they were essentially given different tests. The children in the one word condition were asked to choose the target among other novel objects, none of which were named earlier. This test could easily be interpreted as “pick the one I named earlier” (see Schafer & Plunkett, 1998). Children may have selected the target because the experimenter treated it differently or appeared more interested in that object than the other objects that she did not name (Samuelson & Smith, 1998). Previous research demonstrates that children are very good at selecting an object that is singled out because the experimenter treats it differently (Diesendruck, Markson, Akhtar, & Reudor, 2004; Samuelson & Smith, 1998). Given children’s inability to

retain a single new word after as little as 5 minutes unless ostensive naming or pre-familiarization is provided (Horst & Samuelson, 2008; Kucker & Samuelson, 2012), it is unlikely that children selected the target because they had retained the word-object mapping.

In contrast, in the four words condition, the children were asked to choose the target from among other previously named targets. This test required children to evaluate multiple name-object associations and recognize each name's specific phonetic information (see also Dollaghan, 1985; Schafer & Plunkett, 1998; Wilkinson et al., 2003). As each novel object was named, each object was treated equivalently and none were singled out, providing necessary experimental control. Note, children can succeed at learning multiple words at a time with sufficient support such as repetition (Gurteen et al., 2011), ostensive naming (Axelsson et al., 2012; Horst & Samuelson, 2008), extra semantic cues (Capone & McGregor, 2005) or multiple memory supports (Vlach & Sandhofer, 2012).

In addition to improving experimental control, presenting multiple test trials provides children with multiple opportunities to demonstrate learning. Word learning is not an all-or-none matter but is instead incremental in nature, being both gradual not only across time but also across development (Bion et al., 2013; Carey, 2010; Mather & Plunkett, 2009; McMurray, Horst, & Samuelson, 2012; Smith & Yu, 2008). In everyday life, children hear multiple new words while contending with several representations of previously heard words at varying degrees of strength (Carey, 1978; McMurray, 2007; Smith & Yu, 2008). The children in the four words condition may have formed partial links with one or more of the words and objects. Presenting children with multiple test trials provides them with additional opportunities to

demonstrate and use that partial knowledge. One must be careful, however, because children can do still continue to learn across test trials (McMurray et al., 2012).

It is unsurprising that children in the one word condition performed better because the task demands were clearly different between these two conditions. Clearly, processing one association should be easier than processing multiple associations. But, it is not the numbers or the task effects that are in question. Our point is that the degree of *validity* of these two tests of word learning was different. When one of these things is not like the others (because it is the only one the experimenter named) it stands out as being “special.” When this given item is then presented among only nameless test alternatives the test no longer involves determining which name goes with which object, but to recall which object received special treatment (see also Samuelson & Smith, 1998).

Nonetheless, teaching a single name-object association *may* be an appropriate experimental design. Introducing one novel word when exploring children’s learning and *production* of words may be useful as it is quite difficult for children to learn a word well enough to begin to produce the word and production tasks typically do not involve discrimination between target objects. For example, when attempting to determine how many exposures are necessary for reliable word production, children around 53 months of age required 24 exposures before they produced the new word (Pinkham et al., 2011). Presenting only one word might also be appropriate when exploring whether children can learn anything from conversations where they are not directly addressed (Akhtar et al., 2001) or if children can remember anything from a given situation, especially a difficult one (Horst & Samuelson, 2008). Importantly, such studies address questions of whether children can learn in a given situation *at all*. In contrast, if the goal is to measure or compare the effect(s) of particular factors on

children's word learning (e.g., ostensive naming, Axelsson, Churchley & Horst, 2012), then the test alternatives should be treated equivalently during training. Otherwise, the presence of a single correct test alternative can lead to performance at ceiling, which will mask critical differences between groups.

5. Conclusions

Children acquire new words at a rate of one to four words each day (Bion et al., 2013; Mayor & Plunkett, 2011). Clearly, then, children must be able to learn multiple words at the same time. Building a vocabulary involves learning the meanings of many words in parallel (McMurray, 2007) and as remarkable as this process is, it is slow and gradual (McMurray et al., 2012), requiring many exposures and much repetition (Gurteen et al., 2011; Munro, Baker, McGregor, Docking, & Arciuli, 2012; Pinkham et al., 2011). It is unsurprising that performance was lower in the four words condition. Processing multiple name-object associations is more demanding than processing one; but our point is that if word learning research seeks to test the mechanisms supporting word learning, then we must ensure that children are not simply recalling which object was singled out. Treating all novel objects equivalently and introducing children to more than one novel word (Dollaghan, 1985; Schafer & Plunkett, 1998; Wilkinson et al., 2003) will avoid this confound. Processing multiple words at the same time *is* more difficult, but also allows for a more valid test. Our collective goal is to better understand how children learn words and we know that children can process multiple words in parallel. It is this ability to learn so much at once that makes children's word learning truly remarkable and amazing.

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Table 1. Number of children correct for each target word from the children tested on that word. $*p < .05$ (binomial test).

	<i>Blicket</i>		<i>Chatten</i>		<i>Pizer</i>		<i>Toma</i>	
	One Word	Four Words	One Word	Four Words	One Word	Four Words	One Word	Four Words
Number of correct children (k)	2	3	3*	3	3*	5	3*	4
Number of children tested on this word (N)	3	12	3	12	3	12	3	12
Percentage Correct	67%	25%	100%	25%	100%	42%	100%	33%

Figure Captions

Figure 1. Recall accuracy for new words. Panel A depicts overall accuracy. For the One Word condition the black bar depicts percentage of correct children. For the Four Words condition the white bar depicts percentage of correct trials (error bar represents one standard error). Panel B depicts the number of children who accurately recalled the referent of their first word in the One Word (black bar) and Four Words (white bar) conditions. In both panels the dotted line represents chance; *** $p < 0.001$, two-tailed.

Figure 1.

